InLCA: Selected Papers

Using GaBi 3 to Perform Life Cycle Assessment and Life Cycle Engineering

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Abstract. The growing availability of software tools has increased the speed of generating LCA studies. Databases and visual tools for constructing material balance modules greatly facilitate the process of analyzing the environmental aspects of product systems over their life cycle. A robust software tool, containing a large LCI dataset and functions for performing LCIA and sensitivity analysis will allow companies and LCA practitioners to conduct systems analyses efficiently and reliably. This paper discusses how the GaBi 3 software tool can be used to perform LCA and Life Cycle Engineering (LCE), a methodology that combines life cycle economic, environmental, and technology assessment. The paper highlights important attributes of LCA software tools, including high quality, well-documented data, transparency in modeling, and data analysis functionality. An example of a regional power grid mix model is used to illustrate the versatility of GaBi 3.

Keywords: Analytical tools; decision analysis; GaBi 3; InLCA; LCA methodology; LCA; LCE; Life Cycle Assessment (LCA); Life Cycle Engineering; sensitivity analysis; software tools; system models; systems analysis

1 Introduction

LCA has had a controversial history with some criticism for being costly, time and data intensive, and producing unreliable results. Streamlining techniques in LCA have been discussed in an effort to expedite the process of assessing environmental impacts from product systems [1,2]. Within the last decade however, LCA practitioners have introduced databases contained within software systems, which have greatly assisted the construction of life cycle models, in order to overcome the major criticism of LCA as mentioned above. As the ISO 14040-14043 documents on LCA have been finalized, there is now a clear methodology to be followed for performing LCA [3,4]. With the guidance of the ISO standards, and the more common use of databases and software tools, LCA is receiving wider attention as an applied systems analysis technique [5]. It can be used to highlight the environmental tradeoffs in product design by guiding material selection, identifying the significant stages in the product's life cycle, and guiding product improvement. Also the results of these studies can be used to increase product marketing and sales efforts and to communicate information to customers and clients.

2 Life Cycle Engineering

The Life Cycle Engineering (LCE) approach is an effective framework and methodology for decision support. Like LCA, LCE applies a life cycle framework for the purpose of performing product systems analysis. The LCE approach uses the guidelines defined for LCA in the ISO standards and combines the environmental aspects with technical and economical aspects of products and technologies. It is an effective simulation tool for analyzing weak points and optimization potentials and for supporting product and technology development.

In LCE, the costs associated with materials, energy, and operations are tracked along with the material and energy flows within the system boundary. **Fig. 1** shows the LCE framework in which the technical, economic and ecological components within a system boundary are fed back into the decision-making process.

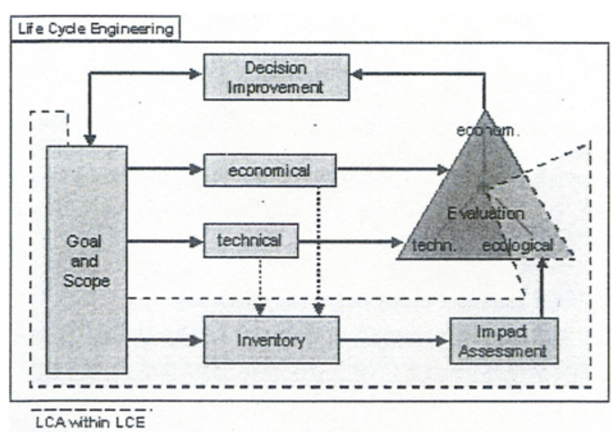

Fig. 1: Life Cycle Engineering (LCE) approach including the Life Cycle Assessment (LCA) [6]

3 Software to support LCA and LCE

Today, there are many software tools available to perform LCA. Altogether, there are about 40 commercial LCA software systems on the market. Software systems that support LCA must ensure transparency in the documentation and analysis of system parameters. Fully ISO compatible tools also enhance the quality of study results. In addition, an ideal software tool should contain an extensive database with indicators of data quality and well-documented data sources. GaBi 3 is among the ten fully integrated and comprehensive software tools around. The authors have performed LCE/LCA studies using GaBi 3 for many product systems. GaBi 3 is the software tool that came as a result of more than 10 years of intensive activities in LCA/LCE research and collaborative industrial projects at IKP and PE. The availability of reliable data (at the moment more than two thousand data sets are available with the software) and functionality for performing transparent case studies, efficiency in analysing LCI results, as well as the flexibility in performing LCIA and evaluation strategies, are some of this tool's most valuable attributes. The GaBi 3 software tool (Fig. 2) supports the systematic preparation and analysis of product- and company-related decisions by integrating technical, economic and ecological aspects in the optimization of production, product design and product marketing. The interface for modeling the systems within GaBi provides a visual map of system boundaries and all flows associated with the system (Sankey diagram).

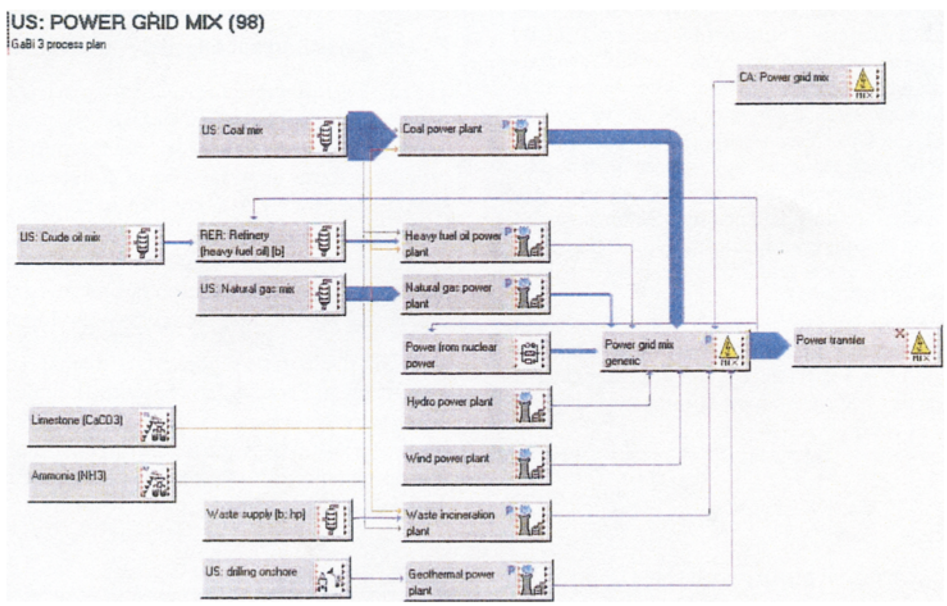

Fig. 2: Plan editor of the GaBi 3 software system showing a model for a regional power grid mix [7,9]

4 Case Example of Software Functionality

Fig. 2 shows an example of a model of the United States' power grid mix, specifically for the 'US total power grid' system as the sum of the ten regional grid mixes defined by Electric Power Annual [11].

As illustrated, the model includes different types of power plants (e.g., hard coal, lignite, heavy fuel oil, natural gas, nuclear, waste incineration, solar, wind and hydro power plant) as well as the corresponding energy carrier supplies. All unit processes marked with a 'P' are set up to use parameters for modeling user-defined conditions for a given process. For example the 'Power grid mix generic' allows the modeler to set different power grid mix compositions (accounting for each fraction of the different types of power plants). In addition, each power plant type is modeled in a detailed manner that takes into account all available information on the regional power grid mixes as defined by the EIA [11]. This includes, as shown in **Fig. 3**, fuel supply chain characteristics and chemical characteristics of the used fuels (e.g., ash-, carbon-, sulfur-content, etc.), energy transformation and generation technologies applied in the power plant (e.g. efficiencies, gas cleaning technologies, etc.) as well as the output combustion products for the different regional power grid mixes. A general description of the models for power generation can be found in the special Japan edition of Int J LCA (LCA in Japan, Vol 5, No 5, 2000) [10].

Each of the above described regional power grid mix operators enable modelers, once such a model is build, to analyze the effects to the environment by technology changes in

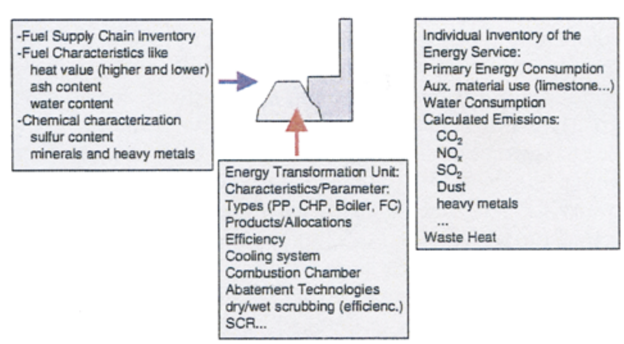

Fig. 3: Structure of a power plant model featuring important fuel and process-related parameters

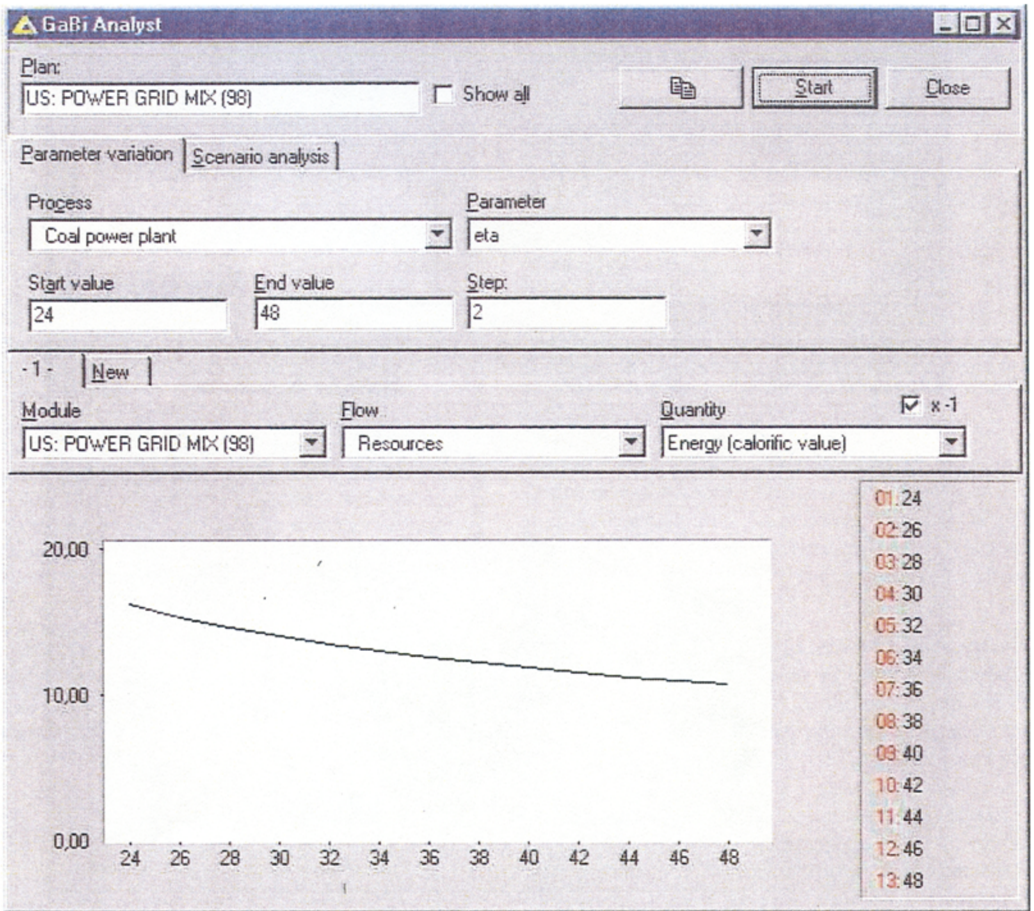

Fig. 4: Parameter variation within the GaBi 3 software system [7,9]

power plant technology (e.g., increase of filter efficiency) or changes in composition of power mix composition (e.g., increase of renewable energy sources or a decrease of hard coal power plants).

In addition, the GaBi 3 software system offers parameter variation and sensitivity analysis functions. These allow the modeler to examine how changes in input parameters or different scenarios affect the inventory results. Both techniques are used to demonstrate the effects of varying important parameters within the models. With this step, the modeler can investigate different future scenarios that may helpful in company planning and strategic decision-making.

Fig. 4 shows the parameter variation function within the GaBi 3 software system. Here, a specific unit process has been identified which includes parameters that have a significant influence on the system. In this case the 'natural gas power plant' is selected with the parameter 'eta' (thermal efficiency of the electricity generation). In the parameter variation the selected parameter is varied from a starting value to an end value (in this case from 24% to 48%). Fig. 4 demonstrates the effect of this change on the primary energy needed to generate 1 kWh of electricity in the US power grid mix. Currently, the thermal efficiency for coal power plants in the US is 33.3% (EIA, Electric Power Annual).

The parameter variation function therefore offers the opportunity to identify the influence of one specific parameter on the total system. In addition, modeled systems often contain several parameters that are sensitive to changes in future scenarios. The GaBi 3 software system offers a scenario analysis function as well. With this functionality, GaBi 3 enables the modeler to calculate possible scenarios or to investigate the sensitivity of a modeled system. In **Fig. 5** an example for a scenario analysis is given. Two scenarios have been selected: the first represents the current situation ('today'); the second one focuses on '2010'. A set of parameters has been identified to be varied for each scenario. The scenarios shown in Fig. 5 examine a change in the thermal efficiency of the coal power plant from 33.3% to 43.3% and a change in the grid mix composition (today: energy from wind from 0.1% to 10% in 2010 and energy from hard coal from 52% today to 42.1% in 2010). The graph in Fig. 5 illustrates two metrics of interest, in light gray the total energy primary demand for the generation of 1kWh and in dark gray the share of renewable energy used. As a result, the total demand on primary energy will decrease from almost 14 MJ/kWh (today) to approx. 10 MJ/kWh (2010). In addition, the graph illustrates that the amount of renewable energy will increase in the same time from approximately 0,5 MJ/kWh up to 2 MJ/KWh.

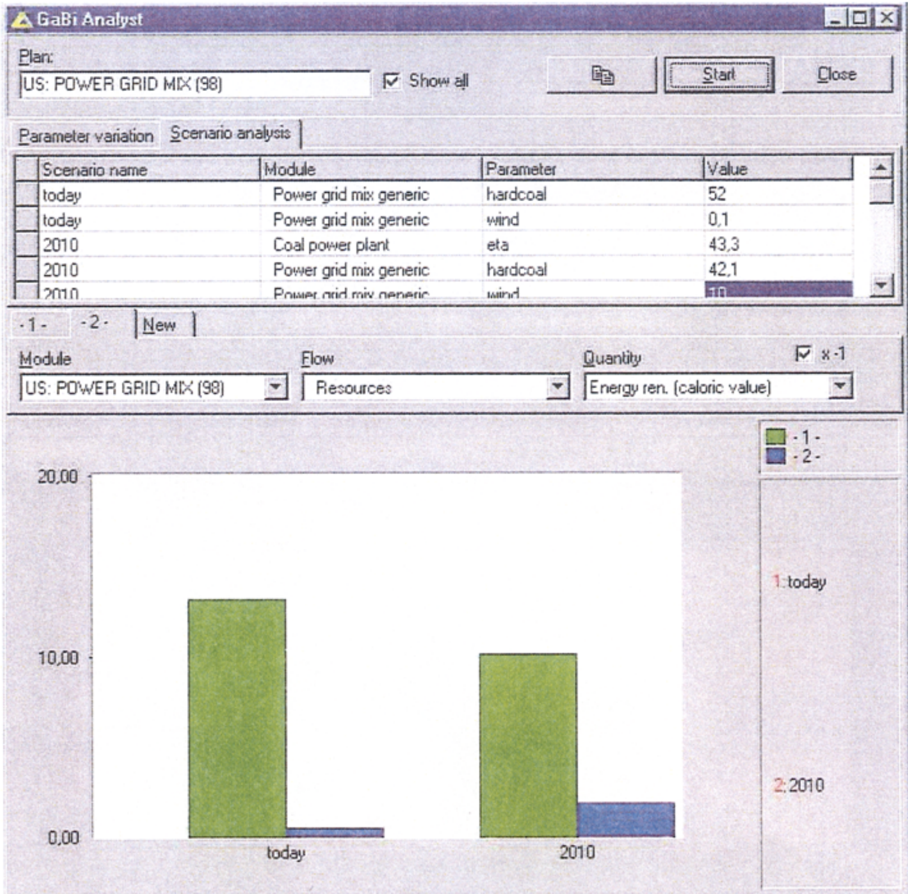

Fig. 5: Parameter variation within the GaBi 3 software system [7,9]

5 Discussion

The practice of LCA has been greatly transformed since tools such as GaBi 3 have been available to practitioners. The software system GaBi 3 has improved the efficiency of performing systems analysis using LCA while maintaining transparency in the modeling process, in the documentation of data quality, and the options available for LCI and LCIA. Therefore GaBi 3 helps reduce time and resources needed to model LCA case studies, while at the same time it provides the information necessary for decision support. In addition the extensive and well-documented database offered through GaBi 3 enables LCA practitioners a comprehensive understanding of the system parameters and system results during the whole life cycle.

With the functionality of GaBi 3, LCA and LCE case studies can be used to get a clear and detailed understanding of the environmental aspects and life cycle environmental impacts of a system. Furthermore, the tool enables the modeler to focus on future scenarios and to determine whether a strategic decision will be sustainable also in the long run.

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